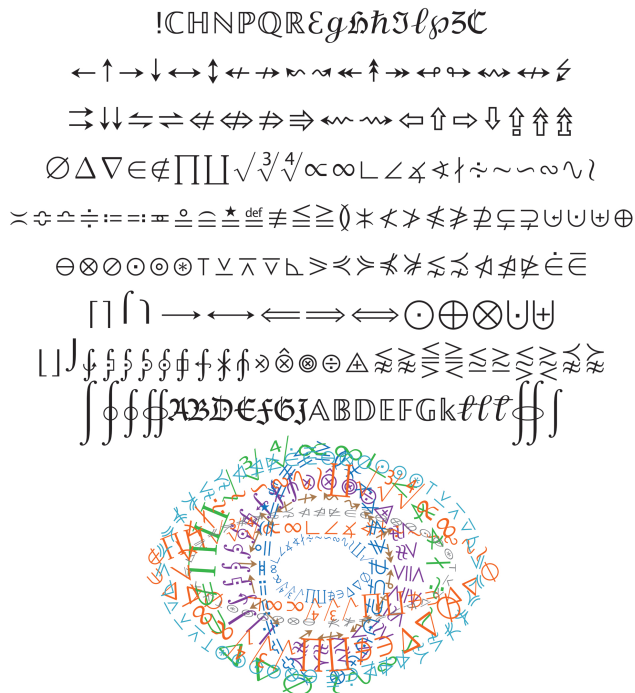


A short history of the Lucida math fonts

Charles Bigelow

This talk is about the development of Lucida math fonts from the beginnings of Lucida in the early 1980s to the most recent Lucida OpenType math fonts of 2011 and later. The images included here, and more, are available online at <http://tug.org/tug2016/slides/bigelow-lucidamath.pdf>.

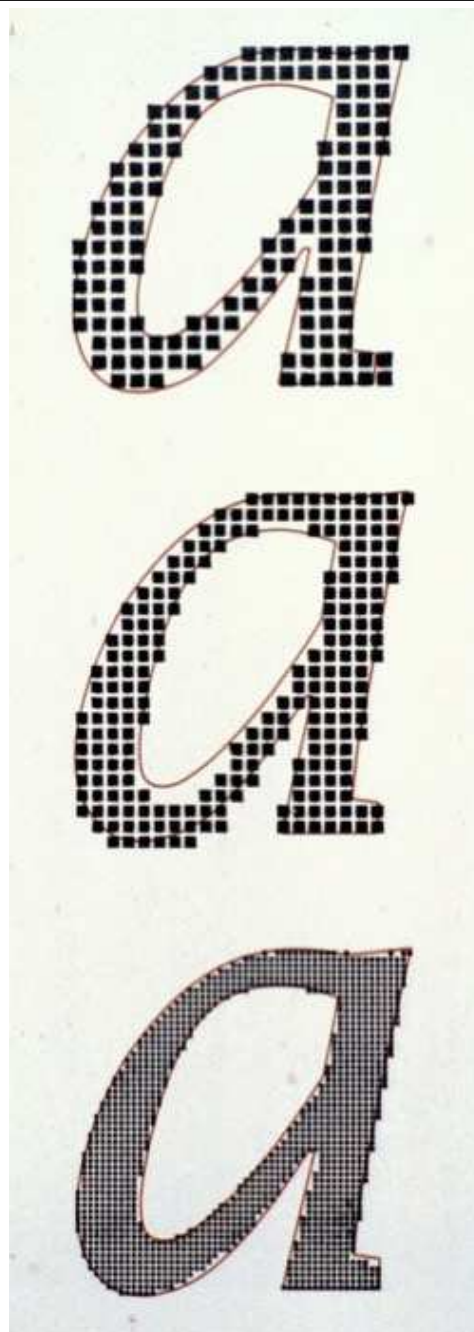


1. The above shows a sampling of characters in Lucida Math fonts. There are letter-like symbols and also different shapes and sizes of arrows, operators, relations, and delimiters.

Typography involves several kinds of harmony between graphical elements. Weight, height, width, stroke thickness, proportions, shapes, orientation, position, spacing, and stylistic features such as serifs, are the main relationships that may have to be harmonized. In the typography of mathematics, many symbols are derived from letters but have become separate semantic elements, not units necessarily combined into words. Within the formal language of mathematics, symbols become ideograms — representing ideas — and logograms — spoken as a word or phrase. Naturally, the spoken version changes from language to language, while the meaning of the symbol is constant. Moreover, symbols for mathematics may need adjustment for optical scale because some may be used large and small. And, of course they must be legible.

Charles Bigelow

2. What were the principles on which Lucida was based? Although we were designing a typeface family for emerging technologies — laser printing and screen display — we tended to look backwards to the history of letter forms, in traditional handwriting or calligraphy, which goes back more than two thousand years for Latin scripts and for more than five hundred years before that for Greek.



3. We wanted the forms of the Lucida letters to be related to traditional scribal handwriting, but not necessarily “calligraphy” in its sense of “beautiful

writing”. Instead we aimed for simplicity because our goal was easy reading under difficult imaging conditions.

Our goal was to adapt traditional forms for simpler rendering at a range of resolutions. We developed the letters in outline formats, principally using Peter Karow’s Ikarus system, but the outlines were then converted to bitmaps, either on-the-fly in printers or pre-rasterized for screens, in the technology of the early 1980s. Laser printers of the late 1970s and early 1980s had addressable resolutions around 240 to 300 dots per inch, and bitmap display screen resolutions were around 70 to 75 pixels per inch on screen.

We made many experiments constructing letters from bitmaps, and then used a few digital systems of the early 1980s to study the different pixel patterns when letters were rasterized at different resolutions. At high resolutions, the letters looked like analog typefaces, but at low resolutions, the letters became minimalist aggregations of dots, and many distinguishing features that separated one type design from another were obscured by the rough, rasterized stair-cased shapes and by data loss.

ABCDEFGHIJKLMN**OP**QRSTUVWXYZ
 abcdefghijklmnopqr**st**uvwxyz
 1234567890

*ABCDEFGHIJKLMN**OP**QRSTUVWXYZ*
*abcdefghijklmn**op**qrst**uv**wxyz*
1234567890

ABCDEFGHIJKLMNOP**QRSTUVWXYZ**
abcdefghijklmnop**qrst**uv**wxyz**
1234567890

4. In 1984, Imagen Corporation released the first Lucida family of seriffed designs. They were simple in form and had several adaptations for lower resolutions, such as short serifs and wide inter-letter spacing to prevent collisions of character elements and clarity at small sizes and greater reading distances from screens, for which loose spacing is often helpful. We made the bold weight with twice the stroke weight of the normal weight, for unambiguous recognition of weight changes at low resolutions. Instead of a “just noticeable difference” we wanted a “dramatically noticeable difference”.

These designs constituted the first new family of types for laser printing and screens. When we developed Lucida, most typefaces being digitized were adaptations of existing metal or photo faces.

The adaptations were sometimes made ethically, but often by plagiarism. We hoped that our development of new digital types would spur more original and more ethical approaches to type, and the Imagen firm, started by graduate students and AI researchers at Stanford, agreed. Another five years went by, however, before major firms began to produce original designs.

With rue my heart is laden
For golden friends I had,
For many a rose-lipt maiden
And many a lightfoot lad

By brooks too broad for leaping
The lightfoot boys are laid;
The rose-lipt girls are sleeping
In fields where roses fade.

A. E. Housman

5. In 1985, also with Imagen, we brought out a sans-serif companion to the original seriffed Lucida family. (The second stanza here shows the sans-serif variants, compared to the seriffed originals in the first stanza.) Many of the sans-serif Lucida features, including slightly darkish weight, generous spacing, big x-height, simple forms, and a humanistic style dating back to legible letters of the Italian Renaissance, made the family ideal for screen displays and user interfaces. Lucida Sans Unicode and Lucida Console have been bundled with Microsoft Windows since the early 1990s, and a version of Lucida Sans, named Lucida Grande (because it had a much bigger character set including Greek, Cyrillic, Hebrew, Arabic, Thai, and many signs and symbols) were adopted as the user interface fonts for Macintosh OS X from the beta tests of 2000 until 2014, when Lucida Grande was replaced by a digitized version of a more traditional “grotesque” sans-serif.

n a x

6. The individual letters of the first Lucida seriffed type were crafted in some unusual ways. Serifs and their brackets and some other features were polygonal

rather than curved. At the time of its design, 1983–1984, some printing and imaging systems used polygonal outlines, whereas other systems used curved contours, including circular arcs or cubic curves in Bezier or Hermite forms. We believed that it would be better to design the polygonal serifs ourselves rather than let some program automatically render them from curved forms. But, we kept curves for the larger aspects of the letters, like arches and bowls.

klmno

7. Here we see diagonal, straight, arched, and fully curved letters in combination, with the characteristic open spacing of the original Lucida.

klmno

klmno

klmno

8. Comparison of the first Lucida (top) to Times Roman (middle), which appeared under its own name and in plagiarized forms under other names, to a modification of Lucida (bottom), fitted to the same widths as Times Roman and with modified serifs but keeping the x-height of Lucida (bottom). It looks condensed because the x-height is greater than that of Times Roman but the width is not. We later released a free version of this design under the name “Luxi Serif”. It can still be found as a free font from web font firms and others. They are gratis but not open source, because we prohibited modification without our permission. We felt that the artistic aspects of the designs should be ours to control.

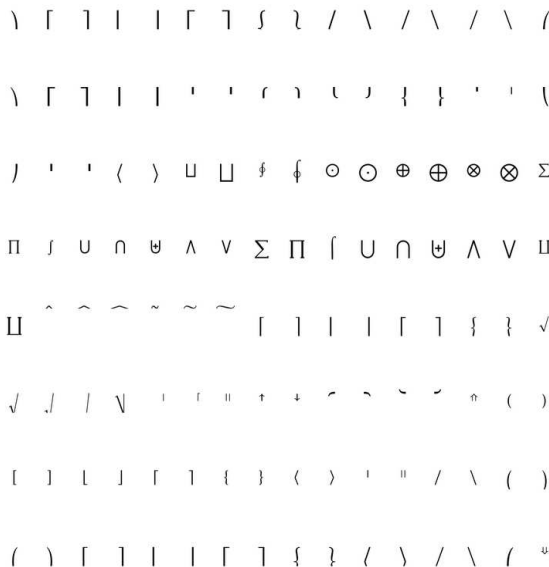
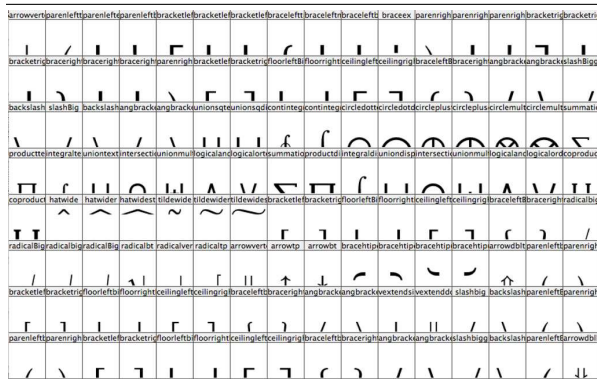
Charles Bigelow

| | | | | | | | | | | | | | | | |
|-----------|----------|----------|-------------|----------|-----------|--------------|-----------|--------------|------------|---------------|-------------|----------|--------------|----------|----------|
| space | comma | period | slash | less | greater | A | B | C | D | E | F | G | H | I | J |
| K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| <i>K</i> | <i>L</i> | <i>M</i> | <i>N</i> | <i>O</i> | <i>P</i> | <i>Q</i> | <i>R</i> | <i>S</i> | <i>T</i> | <i>U</i> | <i>V</i> | <i>W</i> | <i>X</i> | <i>Y</i> | <i>Z</i> |
| a | b | c | d | e | f | g | h | i | j | k | l | m | n | o | p |
| q | r | s | t | u | v | w | x | y | z | mu | dotlessj | dotlessi | epsilon1 | Gamma | Theta |
| <i>q</i> | <i>r</i> | <i>s</i> | <i>t</i> | <i>u</i> | <i>v</i> | <i>w</i> | <i>x</i> | <i>y</i> | <i>z</i> | <i>μ</i> | <i>ı</i> | <i>ϵ</i> | <i>Γ</i> | <i>Θ</i> | |
| Lambda | Xi | Pi | Sigma | Upsilon | Phi | Psi | alpha | beta | gamma | delta | epsilon | zeta | eta | theta | iota |
| <i>Λ</i> | <i>Ξ</i> | <i>Π</i> | <i>Σ</i> | <i>Υ</i> | <i>Φ</i> | <i>Ψ</i> | <i>α</i> | <i>β</i> | <i>γ</i> | <i>δ</i> | <i>ε</i> | <i>ζ</i> | <i>η</i> | <i>θ</i> | <i>ι</i> |
| kappa | lambda | nu | xi | pi | rho | sigma1 | sigma | tau | upsilon | phi | chi | psi | omega | theta1 | phi1 |
| <i>κ</i> | <i>λ</i> | <i>ν</i> | <i>ξ</i> | <i>π</i> | <i>ρ</i> | <i>ς</i> | <i>σ</i> | <i>τ</i> | <i>υ</i> | <i>φ</i> | <i>χ</i> | <i>ψ</i> | <i>ω</i> | <i>θ</i> | <i>φ</i> |
| pi | rho1 | script | Weierstrass | Omega | arrowhook | arrowhookbar | arrowleft | arrowleftbar | arrowright | arrowrightbar | partialdiff | Delta | triangleleft | triangle | star |
| <i>π</i> | <i>ρ</i> | <i>ℓ</i> | <i>℘</i> | <i>Ω</i> | <i>◁</i> | <i>▷</i> | <i>←</i> | <i>↔</i> | <i>→</i> | <i>∂</i> | <i>Δ</i> | <i>▷</i> | <i>◁</i> | <i>★</i> | |
| slurbelow | subbelow | flat | natural | sharp | zeroid | oneid | twoid | threeid | fourid | fiveid | sixid | sevenid | eightid | nineid | vector |
| <i>˘</i> | <i>˙</i> | <i>˚</i> | <i>♮</i> | <i>♯</i> | <i>0</i> | <i>1</i> | <i>2</i> | <i>3</i> | <i>4</i> | <i>5</i> | <i>6</i> | <i>7</i> | <i>8</i> | <i>9</i> | <i>→</i> |

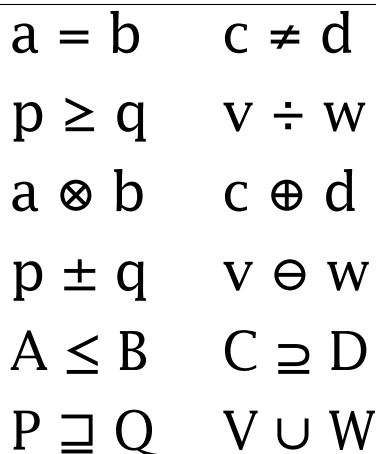
9. Lucida Math Italic, in the same character set as Computer Modern Math Italic. We began the design of math symbols for Lucida in 1985, in part because of the influence of Donald Knuth, who had invited me to join the Stanford faculty and to work with him. If there had been a guide to the various harmonizations needed for math fonts, it would have saved us a lot of effort and time, but there were none, except for examples from which some principles could be inferred. Also, we liked to figure out things by ourselves from first principles. We thought new technologies demanded new design ideas — a lesson we learned by studying with Hermann Zapf — so even had there been guides for math characters, we might have ignored them, being young.

| | | | | | | | | | | | | | | | |
|-------------|---------------|----------------|---------------|---------------|---------------|---------------|---------------|----------------|-----------------|---------------|---------------|---------------|---------------|----------------|---------------|
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
| <i>A</i> | <i>B</i> | <i>C</i> | <i>D</i> | <i>E</i> | <i>F</i> | <i>G</i> | <i>H</i> | <i>I</i> | <i>J</i> | <i>K</i> | <i>L</i> | <i>M</i> | <i>N</i> | <i>O</i> | <i>P</i> |
| Q | R | S | T | U | V | W | X | Y | Z | backslash | bracketleft | bar | bracketright | section | logicalnot |
| <i>Q</i> | <i>R</i> | <i>S</i> | <i>T</i> | <i>U</i> | <i>V</i> | <i>W</i> | <i>X</i> | <i>Y</i> | <i>Z</i> | <i>\</i> | <i>{</i> | <i> </i> | <i>}</i> | <i>§</i> | <i>¬</i> |
| plusminus | paragaph | periodcentered | multiply | divide | dagger | daggerdbl | bullet | Rfractor | aleph | similar | arrowup | arrowupright | arrowdown | arrowdownright | arrowleft |
| <i>±</i> | <i>¶</i> | <i>⋅</i> | <i>×</i> | <i>÷</i> | <i>†</i> | <i>‡</i> | <i>•</i> | <i>ℜ</i> | <i>ℵ</i> | <i>↔</i> | <i>↑</i> | <i>↗</i> | <i>↓</i> | <i>↘</i> | <i>↖</i> |
| arrowright | arrowrightbar | arrowrightbar | arrowrightbar | arrowrightbar | arrowrightbar | arrowrightbar | arrowrightbar | arrowrightbar | arrowrightbar | arrowrightbar | arrowrightbar | arrowrightbar | arrowrightbar | arrowrightbar | arrowrightbar |
| <i>↗</i> | <i>↘</i> | <i>↖</i> | <i>↗</i> | <i>↘</i> | <i>↖</i> | <i>↗</i> | <i>↘</i> | <i>↖</i> | <i>↗</i> | <i>↘</i> | <i>↖</i> | <i>↗</i> | <i>↘</i> | <i>↖</i> | <i>↗</i> |
| infinite | logicaland | logicalor | intersect | union | integral | similar | wreath | approx | equival | quasi | equiv | lesseq | equal | greater | muchgreater |
| <i>∞</i> | <i>∧</i> | <i>∨</i> | <i>∩</i> | <i>∪</i> | <i>∫</i> | <i>~</i> | <i>⋈</i> | <i>≈</i> | <i>≅</i> | <i>≐</i> | <i>≑</i> | <i>≒</i> | <i>≓</i> | <i>≔</i> | <i>≕</i> |
| greateroreq | lesseq | muchgreater | greater | precedes | follows | propersub | propersup | reflexsub | reflexsup | unionmul | subset | superset | intersect | union | sq |
| <i>≥</i> | <i>≤</i> | <i>≫</i> | <i>></i> | <i><</i> | <i>></i> | <i>⊂</i> | <i>⊃</i> | <i>⊆</i> | <i>⊇</i> | <i>⊗</i> | <i>⊆</i> | <i>⊇</i> | <i>∩</i> | <i>∪</i> | <i>⊕</i> |
| circlemul | circlediv | circledot | burnstile | turnstile | lattice | top | perp | di | diamond | ceiling | leftceiling | rightceiling | floorleft | floorright | triangle |
| <i>⊗</i> | <i>⊘</i> | <i>⊙</i> | <i>⊞</i> | <i>⊠</i> | <i>⊡</i> | <i>⊤</i> | <i>⊥</i> | <i>⊢</i> | <i>⊠</i> | <i>⌈</i> | <i>⌈</i> | <i>⌈</i> | <i>⌋</i> | <i>⌋</i> | <i>⊠</i> |
| club | heart | diamond | similareq | prime | negations | mapsto | Rfractor | angbracketleft | angbracketright | bar | dbl | arrowbar | arrowdbl | circ | circ |
| <i>♣</i> | <i>♥</i> | <i>♠</i> | <i>≈</i> | <i>′</i> | <i>¬</i> | <i>↦</i> | <i>ℜ</i> | <i>⟨</i> | <i>⟩</i> | <i> </i> | <i>↕</i> | <i>↕</i> | <i>⊙</i> | <i>⊙</i> | <i>≲</i> |

10. Lucida Math Symbol. We made the strokes of the math symbols fairly thick, in keeping with the general Lucida parameters, and we made many of the symbols fit in the standard figure widths, for easier composition of simple equations and usage in tabular composition, spreadsheets, etc. This tended to make the operators smaller than the letter symbols used for variables. We did this because we thought that the majority of uses of the Lucida math fonts would not be for traditional publishing of mathematics and science, but for simpler uses on screens.



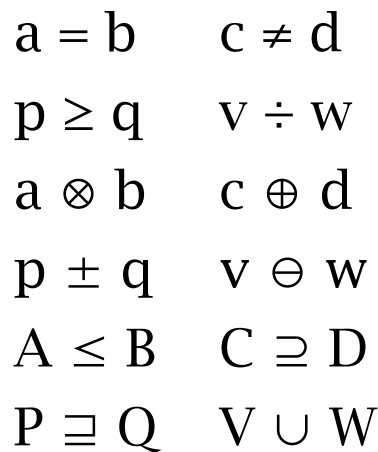
11. We also produced a Lucida Math Extension font. In the first image, you can only see the tops of the characters, because to conform with Donald Knuth’s approach with Computer Modern, many of the big delimiters and extensions “hang” from a central position in the character cell. The second image shows the full characters at a smaller size.



12. Above is the original Lucida math operators of various kinds with lower-case and capital letters. The weights are harmonized and the symbols are clear and resist digital degradation. We developed these math fonts in 1985, but they were not released until 1990 by Adobe. During that time, principally under the influence of PostScript, laser printing became an enabling technology for digital prepress for print publishing, and fonts intended only for lower-resolution printing were less favored. When the original Lucida and Lucida Math fonts were used for more traditionally printed math publishing, they seemed too strong and dark, although they held up well on screens and laser printers. As an editor at one academic press put it, “Lucida Math seemed too aggressively legible”.



13. For print publishing, and now for high resolution screen displays, we prefer legibility (at least when it is more subliminal than aggressive). In 1987, for Scientific American magazine), we made a modification of the original seriffed Lucida with increased contrast of the thick to thin strokes, with more “modern” style serifs, and with tighter letterspacing. An editor at MacWorld magazine said it looked “brighter”, so we named it Lucida Bright. It was used as the body text in Scientific American for nine years.



14. For Lucida Bright, we developed “brightened” math characters. These were released by Microsoft in 1992 in TrueType font format. This prompted requests for T_EX-adapted versions in PostScript format. At this point, we came to realize that the production of fully functional, T_EX-compatible math fonts required more knowledge of T_EX and more effort than we two designers could accomplish on our own.

| | | | | | | | | | |
|----------|----------|----------|----------|----------|----------|----------|----------|----------|---|
| F020 | F021 | F022 | F023 | F024 | F025 | F026 | F027 | F028 | F |
| | + | = | - | · | × | * | ÷ | ◇ | : |
| F030 | F031 | F032 | F033 | F034 | F035 | F036 | F037 | F038 | F |
| ○ | ◦ | ● | ⋈ | ≡ | ⊆ | ⊇ | ≤ | ≥ | : |
| F040 | F041 | F042 | F043 | F044 | F045 | F046 | F047 | F048 | F |
| ≫ | ⋈ | ⋈ | ← | → | ↑ | ↓ | ↔ | ↗ | : |
| F050 | F051 | F052 | F053 | F054 | F055 | F056 | F057 | F058 | F |
| ↖ | ↗ | ∞ | ' | ∞ | ∈ | ⊃ | △ | ▽ | : |
| F060 | F061 | F062 | F063 | F064 | F065 | F066 | F067 | F068 | F |
| ℐ | ℒ | ⊥ | ℵ | ℒ | ℒ | ℒ | ℒ | ℒ | : |
| F070 | F071 | F072 | F073 | F074 | F075 | F076 | F077 | F078 | F |
| <i>M</i> | <i>N</i> | <i>O</i> | <i>P</i> | <i>Q</i> | <i>R</i> | <i>S</i> | <i>T</i> | <i>U</i> | : |
| F080 | F081 | F082 | F083 | F084 | F085 | F086 | F087 | F088 | F |
| ∩ | ⊕ | ∧ | ∨ | ⊢ | ⊣ | ⊥ | ⊥ | ⊥ | : |
| F090 | F091 | F092 | F093 | F094 | F095 | F096 | F097 | F098 | F |
| ↑ | ↕ | ↘ | ↙ | √ | ∏ | ∇ | ∫ | ∪ | : |
| F0A0 | F0A1 | F0A2 | F0A3 | F0A4 | F0A5 | F0A6 | F0A7 | F0A8 | F |
| ∩ | ∪ | ∩ | ∪ | ∩ | ∪ | ∩ | ∪ | ∩ | : |

15. Over the next few years, we worked with Berthold and Blenda Horn, of their firm Y&Y, at turning the Lucida Bright Math fonts into fully functioning PostScript TeX math fonts. It was a tremendous effort made feasible only with the patient and extraordinary collaboration of the Horns.

| | | | | | | | | | |
|------------|------------|------------|------------|----------------|----------------|----------------|----------------|---------------|---------------|
| space | plus | colon | equal | A | B | C | D | E | |
| | + | : | = | <i>A</i> | <i>B</i> | <i>C</i> | <i>D</i> | <i>E</i> | |
| M | N | O | P | Q | R | S | T | U | |
| <i>M</i> | <i>N</i> | <i>O</i> | <i>P</i> | <i>Q</i> | <i>R</i> | <i>S</i> | <i>T</i> | <i>U</i> | |
| bar | braceright | section | logicalnot | plusminus | paraglyph | periodcentered | multiply | divide | dash |
| | } | § | ¬ | ± | ¶ | · | × | ÷ | - |
| arrowup | arrowright | arrowdown | arrowboth | arrownortheast | arrownorthwest | arrowsoutheast | arrowsouthwest | arrowdblright | arrowdblleft |
| ↑ | → | ↓ | ↔ | ↗ | ↖ | ↘ | ↙ | ⇨ | ⇩ |
| increment | nabla | element | ownerright | product | coproduct | summation | minus | minusplus | dot |
| Δ | ∇ | ∈ | ⊃ | ∏ | ∏ | Σ | - | ± | · |
| measured | spherical | logicaland | logicalor | intersect | union | integral | therefore | because | prop |
| ∓ | ⊗ | ∧ | ∨ | ∩ | ∪ | ∫ | ∴ | ∵ | : |
| sine | wreath | pr | minustild | approxore | approxuale | almost | tildetrpl | allegual | equivasyngeor |
| ~ | ⋈ | ≈ | ≅ | ≈ | ≈ | ≈ | ≡ | ⋈ | ⋈ |
| equalcolor | ringinequ | ringequal | correspo | estimates | equiangul | deltaequa | define | equameas | reqques |
| ≡ | ≡ | ≡ | ≡ | ≡ | ≡ | ≡ | ≡ | ≡ | ≡ |
| lessmuch | greaterm | lessequiv | greater | lessore | greater | precedes | follows | precedes | follo |
| ≪ | ≫ | ≪ | ≫ | ≪ | ≫ | ≪ | ≫ | ≪ | ≫ |

16. During this development, we and Y&Y received requests for more math characters, so we kept adding them, and then came more requests for more characters. If we hadn't declared a halt and frozen the

fonts for release, we would probably be adding more characters still. (In truth, we still are, but now to the TUG releases, as we'll see.) To distinguish the Y&Y fonts from the previous Lucida Bright Math, which were in TrueType, not PostScript, and had fewer characters and different encodings, we named the Y&Y releases "Lucida New Math". I suppose we could have called them Lucida Bright Math 2.0, but that would have been confusing, too.

| | | | | | | | | | |
|------|------|------|------|------|------|------|------|------|------|
| 2216 | 2217 | 2218 | 2219 | 221A | 221B | 221C | 221D | 221E | 221F |
| ∖ | * | ○ | ● | √ | ∛ | ∜ | ∞ | ∞ | ∟ |
| 2232 | 2233 | 2234 | 2235 | 2236 | 2237 | 2238 | 2239 | 223A | 223B |
| ℳ | ℳ | ∴ | ∴ | ∴ | ∴ | ∴ | ∴ | ∴ | ∴ |
| 224E | 224F | 2250 | 2251 | 2252 | 2253 | 2254 | 2255 | 2256 | 2257 |
| ∩ | ∩ | ∩ | ∩ | ∩ | ∩ | ∩ | ∩ | ∩ | ∩ |
| 226A | 226B | 226C | 226D | 226E | 226F | 2270 | 2271 | 2272 | 2273 |
| ≪ | ≫ | ∩ | * | ∩ | ∩ | ∩ | ∩ | ∩ | ∩ |
| 2286 | 2287 | 2288 | 2289 | 228A | 228B | 228C | 228D | 228E | 228F |
| ⊆ | ⊇ | ♀ | ♂ | ♀ | ♂ | ∪ | ∪ | ∪ | ∪ |
| 22A2 | 22A3 | 22A4 | 22A5 | 22A6 | 22A7 | 22A8 | 22A9 | 22AA | 22AB |
| ∩ | ∩ | ∩ | ∩ | ∩ | ∩ | ∩ | ∩ | ∩ | ∩ |

17. In the years since the Y&Y versions of the Lucida Bright New Math, the Unicode Consortium added math to the Unicode standard, with hundreds of characters beyond the standard TeX repertoire. Eventually, almost twenty years after the Y&Y Lucida versions, Karl Berry asked (following user requests) if we would like to work on OpenType versions in collaboration with TUG, and we began to work on OpenType versions of Lucida Bright and Lucida Math. The task turned out to be several times greater than the original Y&Y development, and also much greater than we anticipated. Partly because we revised some of our design notions during the development process, and partly because we added hundreds of characters.

| | |
|-----------------|-----------------|
| $a = b$ | $c \neq d$ |
| $a = b$ | $c \neq d$ |
| $a \otimes b$ | $c \oplus d$ |
| $a \oplus b$ | $c \otimes d$ |
| $A \leq B$ | $C \supseteq D$ |
| $A \leq B$ | $C \supseteq D$ |
| $P \supseteq Q$ | $V \cup W$ |
| $P \supseteq Q$ | $V \cup W$ |

18. In developing the OpenType versions, we decided to abandon our original notion that the math operators should match the figure widths; a comparison of the old and new operator sizes is shown above. Our experience over the years suggested that larger operators were more readable by mathematicians. This is anecdotal evidence; we did not conduct controlled laboratory tests of mathematicians reading equations, which should be done. Nevertheless, we made the math symbols bigger. (Interestingly, one of the most prolific legibility researchers of the 20th century, Miles Tinker, wrote his psychology Ph.D. thesis at Stanford in 1927 on “An Experimental study of legibility, perception, and eye movement in the reading of formulae” ... exactly a half-century before Donald Knuth began work on \TeX at Stanford.)

$a = b \quad c + d$
 $\mathbf{a} = \mathbf{b} \quad \mathbf{c} + \mathbf{d}$
 $\mathbf{a} = \mathbf{b} \quad \mathbf{c} + \mathbf{d}$

19. We also made a series of bold weight versions of the math symbols. Unlike the original bold weight of Lucida, which had stems twice as thick as the normal weight, the Lucida Bright bold is more accurately a demibold, with stems 1.5 times as thick as the normal. Still very noticeable but not as domineering in text. (The above shows Lucida Bright Math OT, Lucida Bright Math Demi OT, and the original Lucida Bold.)

Not all these bold characters have well-defined semantics in mathematics, but we became accustomed to requests for such things, so we believed that if we designed the characters, mathematicians would find uses for them.

20. In our experience, and evidently in that of other type designers as well, the development of successful, original typefaces and fonts for mathematics requires technical collaboration. We wish to thank those who helped with the technical aspects of Lucida Math font development. For the Adobe PostScript versions of original Lucida Math: Daniel Mills. For the Y&Y PostScript versions, Lucida New Math: Berthold Horn and Blenda Horn. For the TUG OpenType versions, Lucida Math OT: Karl Berry, Khaled Hosny, and Michael Sharpe, plus a cast of testers, bug reporters, commenters, and other advisers: Barbara Beeton, Hans Hagen, Taco Hoekwater, Bogusław Jackowski, Mojca Miklavc, Norbert Preining, Will Robertson, Ulrik Vieth, Bruno Voisin.

*ABCDEFGHIJ
 KLMNOPQR
 STUVWXYZ*
*ABCDEFGHIJ
 KLMNOPQR
 STUVWXYZ*

21. Work on the Lucida math fonts sometimes resulted in new stand-alone designs, especially scripts. The first such spin-off was “Lucida Calligraphy”, a “brighter” version of the original calligraphic capitals in Lucida Math. Above, the original capitals are shown first, with the bright Lucida capitals below.

Lucida Calligraphy Normal
TEXT SAMPLES | CALLIGRAPHY NARROW NORMAL

*abcdefghijklmnop
 qrstuvwxyz
 ABCDEFGHIJ
 KLMNOPQR
 STUVWXYZ&
 0123456789
 ~!"@#\$%^&*()
 _+=[]\;:./
 { }“”<>?`'-*

22. Here is Lucida Calligraphy in the ASCII set. Originally distributed by Microsoft and now by other vendors, including Monotype. It is based on Italian Renaissance chancery cursive, but, like the other Lucida designs, adapted to digital rendering at a range of resolutions and technologies. We see it almost every day somewhere, often used in some surprising way.

